

**ORIGINATION OF *HIMANTOCERAS* (HETEROMORPHIC AMMONOIDS) RELATED TO PALAEOCEANOGRAPHIC AND CLIMATIC CHANGES DURING THE VALANGINIAN**

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The aim of this work is to investigate the possible connections between ammonoid evolution and palaeoenvironmental changes (modifications in carbon cycle, global cooling and glacio-eustatic events, changes in trophic resources) from the *Campylotoxus* to *Peregrinus* zones (REBOULET *et al.* 2006), stratigraphic interval for which recent data on palaeoceanographic and climatic conditions are available (Pucéat *et al.*, 2003; McArthur *et al.*, 2007).

In SE France basin, in the *Biassalense* and *Verrucosum* subzones, a large majority of the typically Lower Valanginian ammonoid genera and species disappears (*Busnardoites*, *Kilianella*, *Saynoceras*, *Valanginites*, etc. (Reboulet, 1996; Reboulet & Atrops, 1999). Even if some genera cross this extinction phase, they decline rapidly and are much less abundant in the Upper Valanginian. *Neocomites* appears at the top of *Biassalense* subzone; it will be at the origin of the Upper Valanginian neocomitids. This genus is also the ancestor of *Himantoceras*, heteromorphic ammonoids which appear at the base of the Nicklesi subzone, by way of *Neocomites beaumugnensis*, *Rodighierites belimelensis* and *R. cardulus*; this phyletic trend takes place during the Pronecostatum subzone and *Peregrinus* zone (Reboulet, 1996).

Perturbations in the global carbon cycle are the final expression of large-scale and rapid environmental changes which could have

affected the biota. The *Biassalense-Verrucosum* subzones are characterized by a positive  $\delta^{13}\text{C}$  excursion, correlated with the Valanginian Weissert OAE (McArthur *et al.*, 2007, and references therein). The major extinction event in the history of Valanginian ammonoids occurs simultaneously with a global perturbation of the carbon cycle which takes place across the Lower-Upper Valanginian boundary. The *Verrucosum* subzone is also characterized by the disappearance of several species and genera of belemnites (Janssen & Clément, 2002). The faunal caesura in the evolution of these cephalopods is followed by the origination of *Himantoceras* which takes place during the decrease of carbon isotope values. Similar observations have been made in the Bajocian of Betic Cordillera (Spain). The origination of uncoiled *Spiroceras* coincides with a shift to lighter values in  $\delta^{13}\text{C}$  and it is associated with a major ammonoid extinction (O'Dogherty *et al.*, 2006).

An important decrease in sea-water temperature (around 7°C) is recorded in the Western Tethyan marine basins between the Lower and Upper Valanginian (Pucéat *et al.*, 2003) and the maximum cooling probably takes place in the *Peregrinus* subzone (McArthur *et al.*, 2007). A significant sea level drop, partly caused by the formation of polar ice during this cooling event, could explain the extinction of numerous ammonoid taxa due to

the reduction of their habitat space in proximal palaeoenvironments (for example, exposure of Provence platform). The decrease in sea-water temperature is also an important stress factor for these Tethyan species. The evolutionary trend of *Neocomites* towards *Himantoceras* (during *Pronecostatum*-*Peregrinus* subzones) takes place just after the major extinction event. This probably results in decreased competition for habitats after the disappearance of numerous species. The change in geometry shell (from involute/evolute planispirals to uncoiled ammonoids) occurs during high environmental stress generated by a major sea-level lowstand and the maximum sea-water cooling which takes place during the *Peregrinus* zone.

Trophic resources in the water column was an important factor controlling the diversity and abundance of ammonoids with respect to their habitat and mode of life. Heteromorphs probably had different trophic behaviour than involute/evolute planispirals; the former probably could better occupy new ecological niches (Reboulet *et al.* 2005). A quantitative study made in the uppermost Albian of the SE France basin has shown that involute/evolute planispirals are abundant during intervals characterized by oligotrophic conditions and stable conditions. Albian heteromorphs, which are dominant during mesotrophic conditions, could have been more competitive than involute/evolute planispirals when palaeoenvironmental conditions become more unstable caused by periods of increased precipitation, fresh-water input and introduction of associated nutrients into marine realm (Reboulet *et al.* 2005). The disappearance of numerous planispiral ammonoid species across the Lower-Upper Valanginian boundary and the origination of heteromorphs in the

*Peregrinus* zone could be due to variations in sea-water productivity and food availability during unstable conditions.

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